

The Trapezium of Orion. By S. W. Burnham, M.A.

Perhaps no object in the sidereal heavens has received more attention from astronomers than the multiple star θ *Orionis*. It has been the subject of careful study by the most eminent observers, provided with the best astronomical instruments; and the relative positions of the principal stars have been determined with the greatest possible accuracy. Certainly no equal area in any other part of the sky has furnished room for the location of so many purely imaginary stars. At intervals during the last fifty years various observers have recorded a number of stars in the space enclosed by the four bright stars of the trapezium. As a rule these alleged discoveries have been made with small telescopes, even down to four inches' aperture, and by observers with little or no experience in double-star work. As would be expected, perhaps, in an object as carefully studied as this has been for the last twenty or thirty years, all the large and most perfect modern refractors, directed by the most experienced double-star observers, have utterly failed to show, under the best atmospheric conditions, the least trace of a single one of the dozen or more supposed new stars. The great 26-inch at Washington, until recently the most powerful telescope in the world, revealed nothing to Hall in the course of a long series of measures of the known stars of this group. The other large telescopes in this country—the McCormick 26-inch, the Princeton 23-inch, the Chicago 18½-inch, the Madison 16-inch, and the Harvard 15½-inch—were equally unsuccessful.

The trapezium was carefully examined by me with the Chicago telescope, at times under very favourable circumstances, and as the result of the search for the new stars (*Mem. R.A.S.* vol. xlv. p. 99) I stated:—

“Several observers have seen, or believe they have seen, minute stars in the trapezium. . . . While making the measures given above, and at other times, under very favourable conditions, the interior of the trapezium and the vicinity of the principal stars were carefully examined. There was not the slightest suspicion of any additional stars. If the sixth star itself had been double, with a distance of 1'', it could not have been overlooked. I have very little faith in the real existence of these suspected stars after the failure of this and other large refractors to show them. It is wholly improbable that they should be variable in such a manner as to render them at all times invisible within the last few years. In regard to the alleged variability of the fifth and sixth stars, I can only say that they have always been readily seen with my 6-inch in the last six years when the atmospheric conditions were suitable. So far as my observations go there appears to be no evidence of change in the light of these stars.”

Hall, after giving an elaborate series of measures of the principal stars (*Washington Observations*, 1877), states, "During my observations I never saw any star within the trapezium, and several careful examinations were made."

And yet one observer with a 12-inch mirror has recorded, "In the trapezium nine stars certainly, ten probably, were visible;" all of which is sufficiently indefinite to anticipate any real discovery now or hereafter. In fact it would be impossible to place a star within the trapezium which could not be claimed as identical with some of the stars referred to.

It is not difficult to understand how, in a region of this character, with a nebulous background, and surrounded by bright stars, faint points of light might be suspected; but it is past comprehension that the observer, before making any announcement, should not satisfy himself by repeated observations of the actual existence of the suspected stars, and, having done that, should not have attempted to fix their places by some tangible evidence. Apparently there has never been any effort to determine their positions by micrometrical measures, and we have only diagrams and descriptions, more or less vague, from which to locate the suspected objects. Examples of this kind are found in the imaginary companions to *Vega*, ϵ *Lyræ*, *Polaris*, *Sirius*, &c., which have long been known to be purely mythical. Mr. Sadler has carefully compiled the observations relating to new stars within the trapezium (*English Mechanic*, Jan. 13, 1882), and given in a diagram, as accurately as possible, the places of the several stars.

When the 36-inch refractor of the Lick Observatory was mounted, one of the first objects examined by Mr. Alvan G. Clark, the maker of the object-glass, was the trapezium of *Orion*; and he detected at once an exceedingly faint point of light within the trapezium, and nearly equidistant from the large stars C and D. Since that time this star has been repeatedly seen and measured by me, and, although a difficult object with the great telescope, there is certainly no doubt of its reality. It is not very far from the limit of a 36-inch aperture, and can only be seen with this instrument in a very good, steady air. It will stand very little magnifying, and is best seen with the lowest micrometer eye-pieces, powers 390 and 450. I have called the magnitude of this star 16, but I think the brightness is really over-estimated, the limit of the instrument being 17.0 on Argelander's scale. I have never seen with this or any other telescope so faint a star, or one so difficult to measure. It would be overlooked by any but the most careful observer even with this telescope on the very best nights, and is absolutely invisible to me when the seeing is not first class.

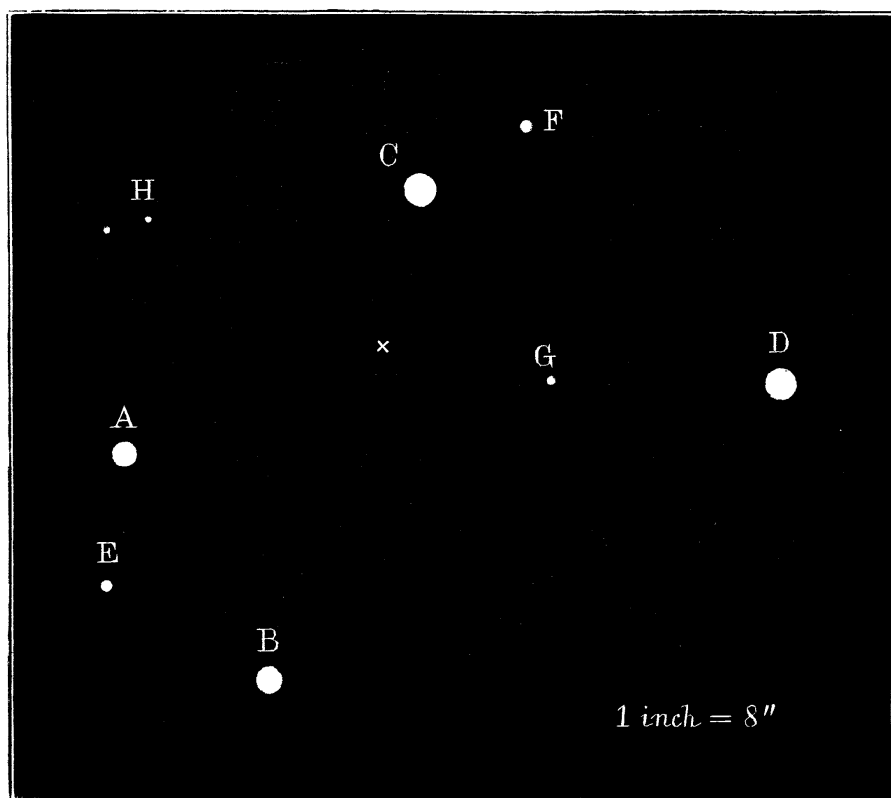
In October of the past year Mr. Barnard, of this Observatory, detected another new star just preceding the trapezium, which had been missed by all who had examined it with this telescope. It is about the same magnitude as the Clark star, and quite as

difficult to measure. He also saw that this exceedingly faint star was itself double, but I was unable to see the two components on any night when it was measured from the bright stars of the trapezium. Later, and on a remarkably perfect night, I saw the minute pair well, though with great difficulty, and obtained a fairly good measure. As a double star it is quite unlike anything known in the heavens, and the severest possible test for the defining and illuminating power of the large telescope. I have only been able to see it once.

No one who had seen either the Clark or the Barnard star with this instrument would for a moment doubt that they are beyond the reach of all other large telescopes. Possibly the Nice 30-inch may show them, but, from the difficulty of the observations here, I think it very improbable. The 30-inch at Pulkowa may be too far north.

Mr. Barnard has also discovered a second star within the trapezium, more centrally placed than the other, of the existence of which he has no question, having seen it on two occasions. I have not satisfactorily seen this star, and cannot speak of it from personal knowledge, but, from Mr. Barnard's great experience in studying very faint objects and his remarkable acuteness of vision, I am confident this new star will be found where he saw it, nearly on the diagonal from B to C. Down to this time I have found no night perfect enough to deal with it. It is certainly very much fainter than either of the other stars.

The accompanying diagram, drawn to scale (1 inch = 8"), will



April 1889.

Trapezium of Orion.

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- indicate the relative positions of the several stars as derived from my measures. The unmeasured new star is indicated by a small cross.

The following measures were made by me with the 36-inch. The faint stars were usually measured with a power of 450, and the brighter stars with 670 and 1030. The Struve letters are used for the bright stars, the new stars being represented by the succeeding letters, and their magnitudes by the numbers in the fourth column :—

C and G. (Clark's star.)

1888·856	31·7	7 ^{''} 66			
1888·928	32·7	7·31	.	.	16
1889·049	37·9	7·81			
1889·077	32·6	6·83	.	.	16
1888·98	33·9	7·40			

D and G.

1888·856	273·1	7·45
1888·928	267·9	7·12
1889·049	272·1	6·56
1889·077	269·1	6·99
1888·98	270·5	7·03

A and H. (Barnard's star.)

1888·928	178·6	7·74	.	.	16
1889·077	178·2	8·14	.	.	16
1889·00	178·4	7·94			

C and H.

1888·928	275·1	9·17
1889·049	276·1	8·41
1889·077	275·7	8·29
1889·02	275·6	8·62

H¹ and H². (Barnard's pair.)

1889·073	274·0	1·32	.	.	16...16·5
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Excessively difficult.

A and B.

1888·862	31·8	8·66
·879	32·3	8·86
·895	32·7	8·70
1888·88	32·3	8·74

A and C.

1888 862	131 ⁰ 5	13 ⁰⁰
·879	131 ¹ 2	13 ⁰⁶
·895	131 ¹ 1	12 ⁷⁹
1888·88	131 ¹ 3	12 ⁹⁵

D and C.

1888·856	241 ⁷	13 ²³
·862	241 ¹ 1	13 ⁴⁸
·879	241 ¹ 1	13 ³⁵
1888·87	241 ¹ 3	13 ³⁵

D and B.

1888·862	299 ⁴	19 ³⁵
·879	299 ⁴	19 ³³
·895	299 ⁷	19 ⁵⁰
1888·88	299 ⁵	19 ³⁹

B and C.

1888·862	162 ⁹	16 ⁸⁷
·879	163 ³	16 ⁷⁰
·895	162 ⁷	16 ⁷¹
1888·88	163 ⁰	16 ⁷⁶

A and D.

1888·862	95 ³	21 ⁵⁷
·879	95 ⁵	21 ⁵⁵
·895	95 ⁴	21 ⁵⁴
1888·88	95 ⁴	21 ⁵⁵

A and E. (Fifth star.)

1888·862	352 ⁰	4 ²⁸
·879	352 ⁴	4 ³⁰
·895	350 ¹	4 ³⁶
1888·88	351 ⁵	4 ³¹

C and F. (Sixth star.)

1888·854	121 ³	4 ⁰⁵
·856	121 ⁸	4 ⁰⁶
·862	119 ⁵	3 ⁸⁶
1888·86	120 ⁹	3 ⁹⁹

As a test of the consistency, if not the accuracy, of the measures of position-angles, the following may be of some interest:—

Trapezium ABCD.

Angle A = 99°0

B = 92°8

C = 110°0

D = 58°2

360°0

Triangle ACD.

Angle CAD = 35°9

ACD = 110°0

ADC = 34°1

180°0

Triangle ADB.

Angle BAD = 63°1

ABD = 92°8

ADB = 24°1

180°0

Triangle CDG. (Clark's star.)

Angle DCG = 27°4

CDG = 29°2

CGD = 123°4

180°0

Triangle ACH. (Barnard's star.)

Angle CAH = 47°1

ACH = 35°7

AHC = 97°2

180°0

The absence of any sensible change in the relative positions of the principal stars will be apparent from a comparison of these with the earlier measures of Struve and others. The number of nights of observation is given in the fourth column.

A and B.

1836·15	31°6	8°71	3n	Struve.
1873·69	31°8	8°61	2n	O. Struve.
1878·17	33°5	8°80	6n	Hall.
1888·88	32°3	8°74	3n	Burnham.

A and C.

1836·15	131°6	13°00	3n	Struve.
1868·20	132°4	13°25	5n	O. Struve.
1878·14	130°7	13°20	7n	Hall.
1888·88	131°3	12°95	3n	Burnham.

D and C.

1836.15	240°3	13'34"	3 _n	Struve.
1868.20	241°8	13'41	5 _n	O. Struve.
1878.16	241°5	13'41	7 _n	Hall.
1888.87	241°3	13'35	3 _n	Burnham.

D and B.

1836.15	299.4	19.23	3 _n	Struve.
1873.69	300°2	19.29	2 _n	O. Struve.
1878.17	299.2	19.39	6 _n	Hall.
1888.88	299.5	19.39	3 _n	Burnham.

B and C.

1836.15	162.1	16.85	3 _n	Struve.
1868.20	163.6	16.89	5 _n	O. Struve.
1878.16	162.5	16.77	7 _n	Hall.
1888.88	163.0	16.76	3 _n	Burnham.

A and D.

1836.15	95.4	21.41	3 _n	Struve.
1872.20	95.2	21.40	3 _n	O. Struve.
1878.17	95.6	21.67	7 _n	Hall.
1888.88	95.4	21.55	3 _n	Burnham.

A and E.

1832.53	353.6	3.86	7 _n	Struve.
1859.62	350.8	4.29	4 _n	O. Struve.
1877.10	351.5	4.21	4 _n	Hall.
1888.88	351.5	4.31	3 _n	Burnham.

C and F.

1846.66	125.9	3.28	2 _n	Struve.
1858.85	128.8	3.93	5 _n	O. Struve.
1877.10	120.	4.00	4 _n	Hall.
1888.86	120.9	3.99	3 _n	Burnham.

The trifling differences in the measures of the fifth and sixth stars are undoubtedly due to errors of observation. As a multiple star it is wholly wanting in interest so far as relative motion is concerned.

Mount Hamilton :
1889, *March 1.*

Probable Errors of Greenwich Determinations of Right Ascension at different Zenith Distances. By A. M. W. Downing, M.A.

The observations used in computing these probable errors are chiefly those made in the years 1886 and 1887. In some of the groups observations made in 1885 have also been included. For the close polar stars, which are used for determination of the azimuth error of the Transit-Circle, the observations made in the years 1880-87 have been utilised, in order to get a sufficient number of observations of each star. As these stars were observed by the eye-and-ear method, the results for them are placed in a separate table, as not being comparable with the results obtained for stars observed by the chronographic method. In Table II., giving the results for south stars, I have added, for comparison, the probable errors computed by Mr. Dunkin from the Greenwich observations for 1857, printed in the *Monthly Notices*, vol. xx. p. 88. In the case of *Polaris* (Table III.) it was found that the probable errors deduced from the observations in 1885-87 were distinctly smaller than those found for the other azimuth stars from the observations made in 1880-87. It was thought that this might possibly arise from a change in the method of observing these close polar stars introduced at the beginning of 1885, viz. moving the system of vertical threads by means of the micrometer screw during the star's transit, so that a considerably greater number of separate observations could be obtained at the same transit than was formerly possible. The probable errors for *Polaris* were therefore computed afresh from the observations made in 1880-82, and these, although slightly larger than the former values, are still distinctly smaller than the values obtained for the other close polar stars. It would appear, therefore, that the determinations of right ascension of *Polaris* are more accurate (as estimated by discordance from the mean) than those of the other close polar stars which are used for determination of azimuth error. It will be remembered that the deduced right ascensions of these stars depend on azimuth errors determined from at least two consecutive transits of *Polaris* and *Polaris S.P.*, and are therefore independent of the assumed place of that star.

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